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(54) **STEREOSCOPIC DISPLAY DEVICE**

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G06F 3/03 (2006.01)
(Continued)

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CPC ***G02B 27/2214*** (2013.01); ***G06F 3/03*** (2013.01); ***G06F 3/0416*** (2013.01); ***H04N 13/0409*** (2013.01); *G02F 1/13471* (2013.01); *G02F 2201/44* (2013.01)

(58) **Field of Classification Search**
CPC G02B 27/2214; G02F 1/13471; G02F 2201/44; G06F 3/03; G06F 3/0416; H04N 13/0409
See application file for complete search history.

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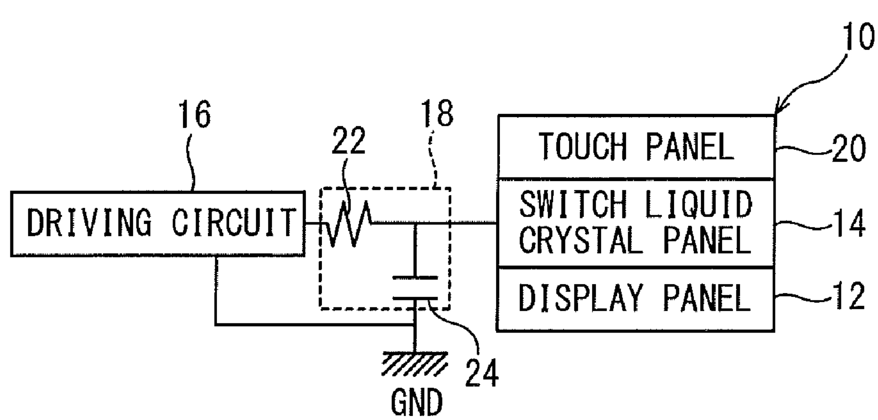
(74) *Attorney, Agent, or Firm* — Keating & Bennett, LLP

(57) **ABSTRACT**

The objective is to provide a stereoscopic display device that is capable of preventing a malfunction of the touch panel while maintaining 3D capability. The device includes: a display panel (**12**); a switch liquid crystal panel (**14**); a touch panel (**20**); a driving circuit (**16**); and an RC circuit (**18**). The switch liquid crystal panel (**14**) is located on the front side of the display panel (**12**) and is capable of forming a parallax barrier (**38**). The touch panel (**20**) is located on the front side of the switch liquid crystal panel (**14**). The driving circuit (**16**) drives the switch liquid crystal panel (**14**) to form the parallax barrier (**38**). The RC circuit (**18**) is located between the switch liquid crystal panel (**14**) and the driving circuit (**16**). The driving circuit (**16**) drives the switch liquid crystal panel (**14**) using a voltage with an effective value of 3 volts or more.

7 Claims, 9 Drawing Sheets



(51) **Int. Cl.**

G02F 1/133	(2006.01)
G02F 1/1343	(2006.01)
H04N 13/04	(2006.01)
G06F 3/041	(2006.01)
G02F 1/1347	(2006.01)

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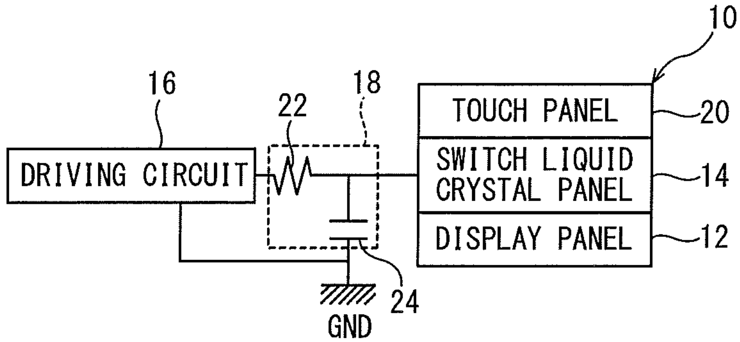
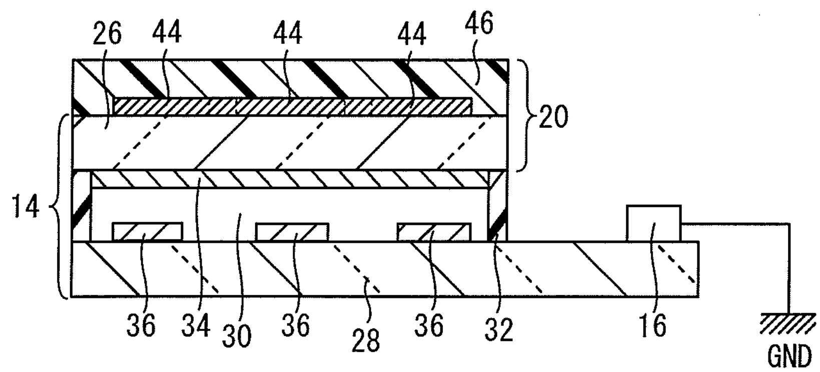

10
16
22
18
TOUCH PANEL
20
DRIVING CIRCUIT
SWITCH LIQUID
CRYSTAL PANEL
14
DISPLAY PANEL
12
24
GND

FIG. 1


26
44
44
44
46
20
14
36
34
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36
28
36
32
16
GND

FIG. 2

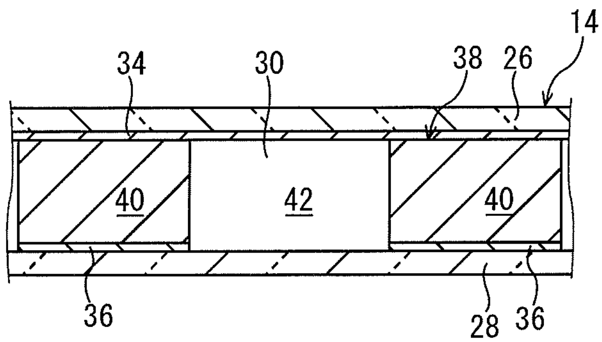


FIG. 3

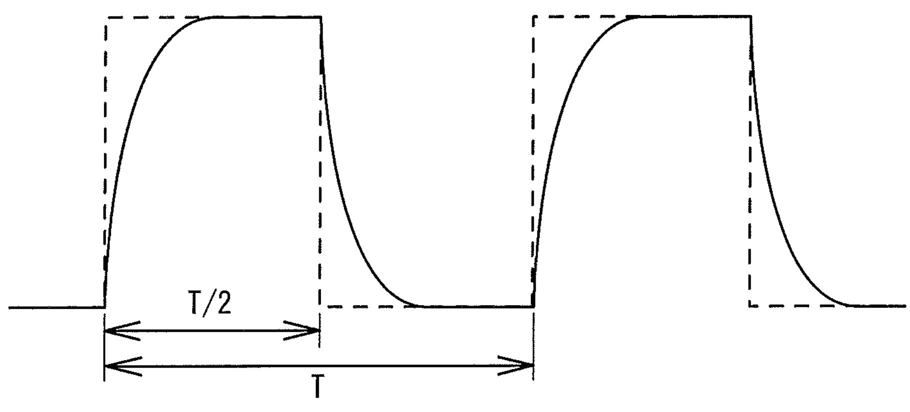
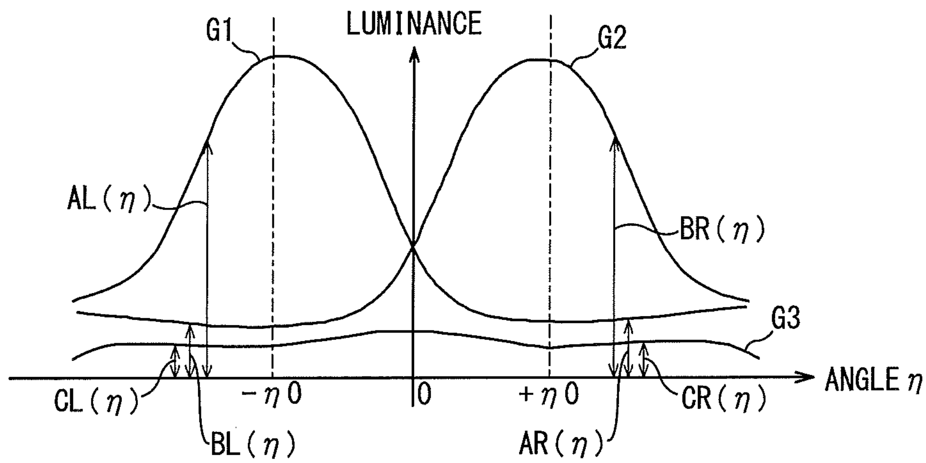
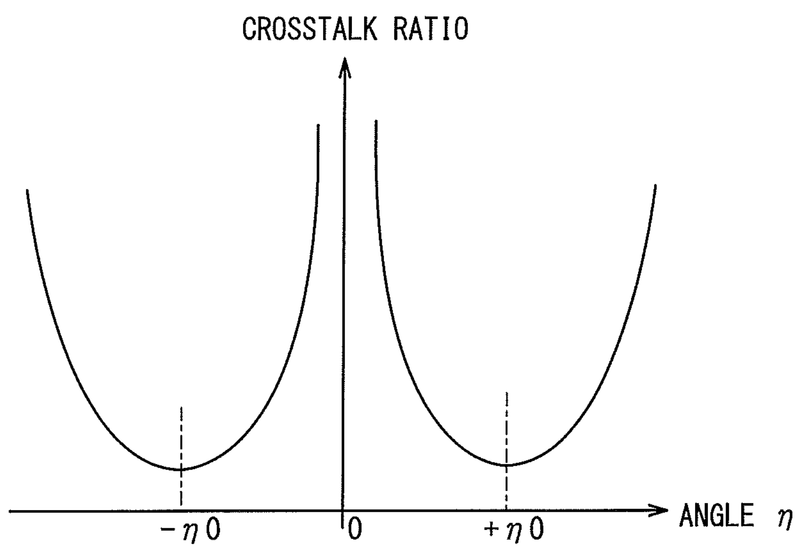


FIG. 4



G1
LUMINANCE
G2
AL(η)
BR(η)
G3
ANGLE η
CL(η)
−η0
0
+η0
CR(η)
BL(η)
AR(η)

FIG. 5



CROSSTALK RATIO
ANGLE η
−η0
0
+η0

FIG. 6

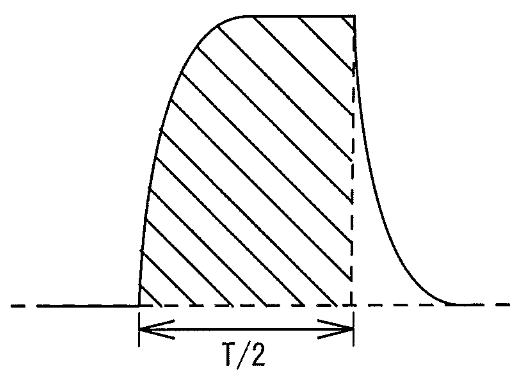


FIG. 7

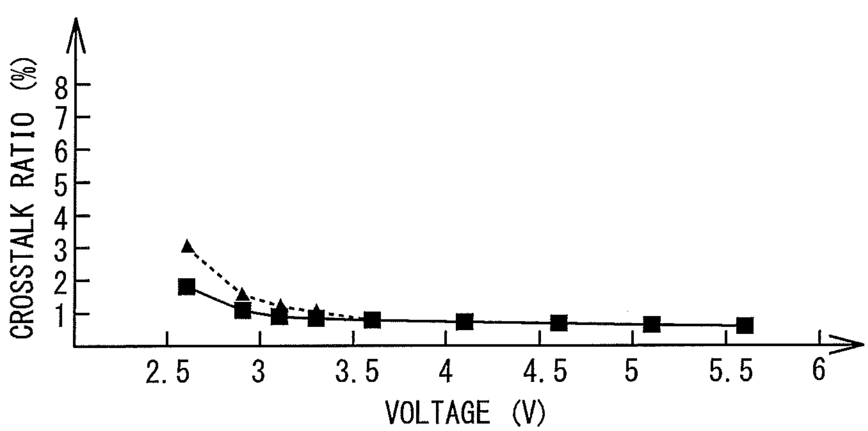


FIG. 8

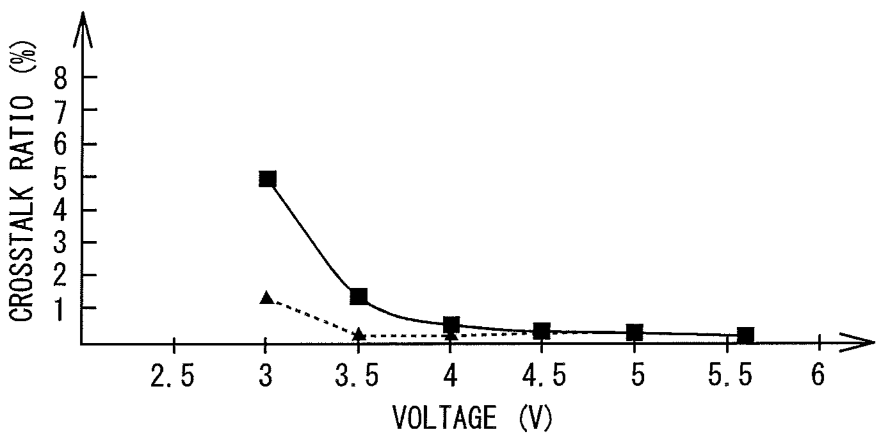

CROSSTALK RATIO (%)
8
7
6
5
4
3
2
1
2.5
3
3.5
4
4.5
5
5.5
6
VOLTAGE (V)

FIG. 9

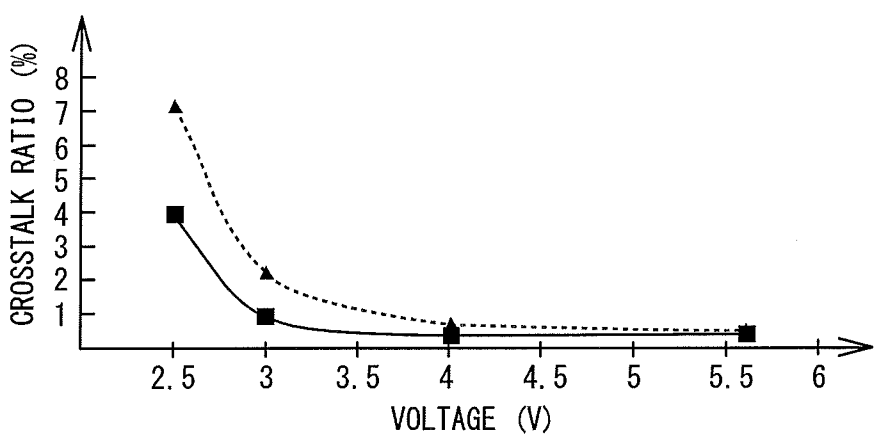

CROSSTALK RATIO (%)
8
7
6
5
4
3
2
1
2.5
3
3.5
4
4.5
5
5.5
6
VOLTAGE (V)

FIG. 10

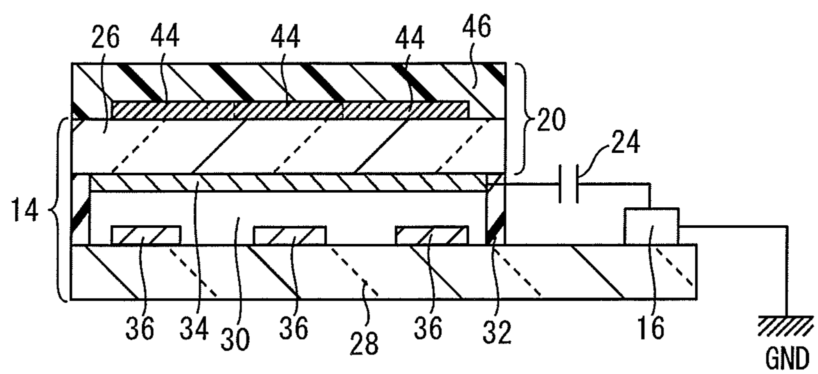


FIG. 11

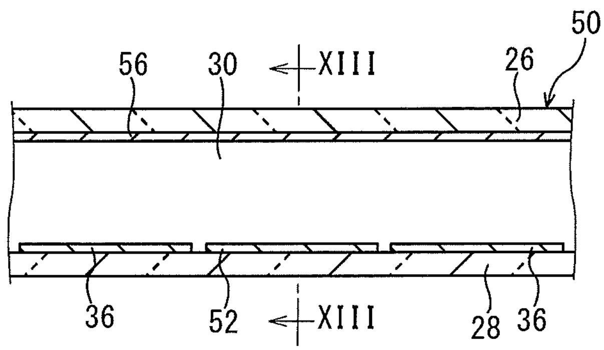


FIG. 12

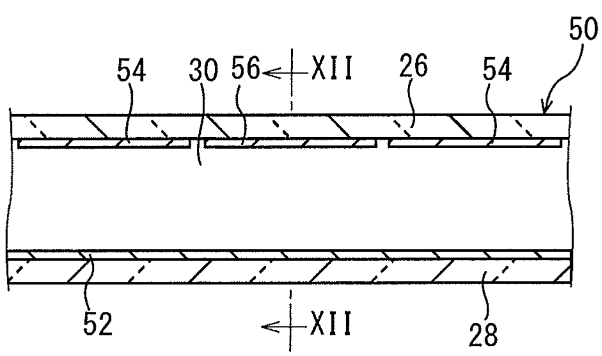


FIG. 13

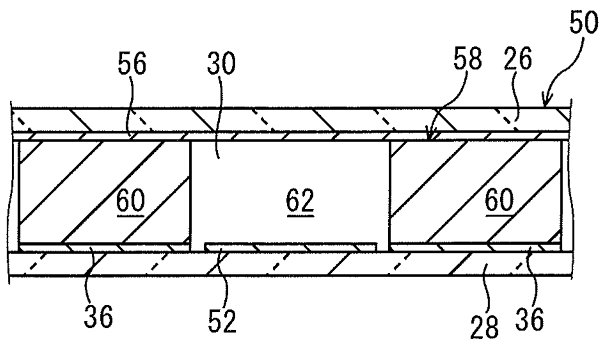


FIG. 14

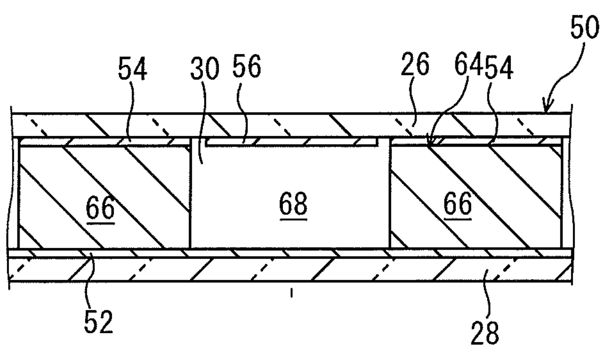


FIG. 15

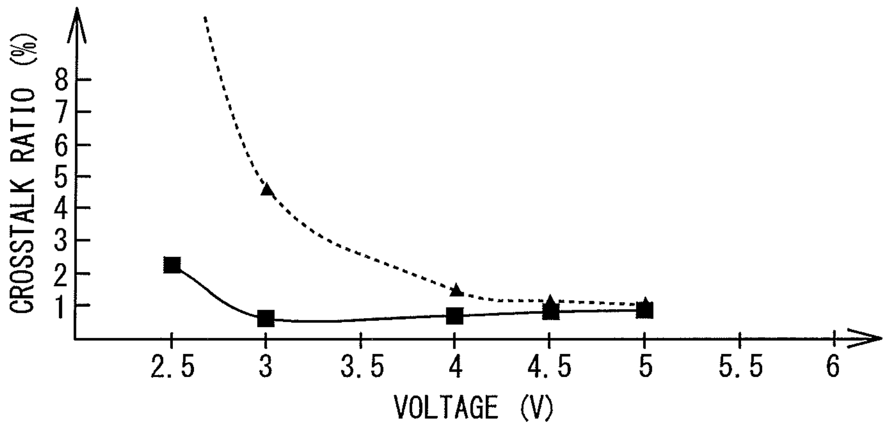

CROSSTALK RATIO (%)
8
7
6
5
4
3
2
1
2.5
3
3.5
4
4.5
5
5.5
6
VOLTAGE (V)

FIG. 16

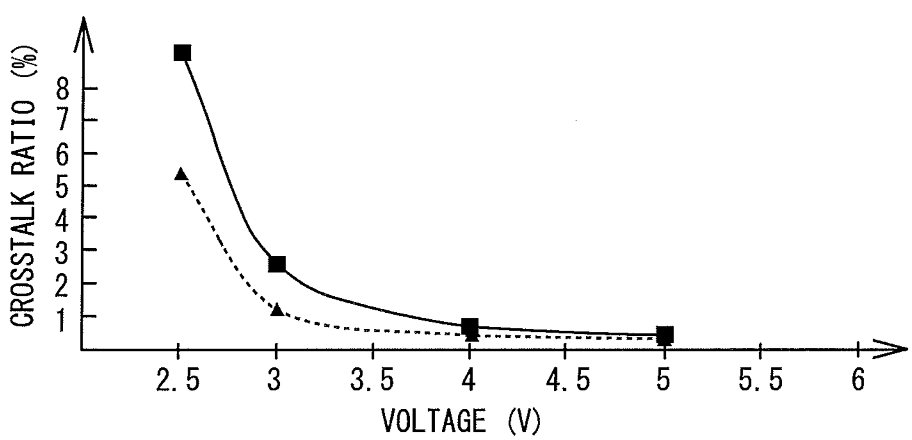

CROSSTALK RATIO (%)
8
7
6
5
4
3
2
1
2.5
3
3.5
4
4.5
5
5.5
6
VOLTAGE (V)

FIG. 17

STEREOSCOPIC DISPLAY DEVICE

TECHNICAL FIELD

The present invention relates to a stereoscopic display device including a touch panel and a switch liquid crystal panel.

BACKGROUND ART

Display devices including touch panels are known. With such a display device, it is necessary to prevent a malfunction of the touch panel.

JP 2010-197570 A discloses a liquid crystal display device that is capable of reducing noise which would cause a malfunction of the touch panel. The liquid crystal display device described in this publication includes a pre-charge circuit. The pre-charge circuit pre-charges all the signal lines during a horizontal blanking period before an analog pixel voltage is supplied to the signal lines. Thus, the voltages on the signal lines do not change rapidly. As a result, less noise is generated from the liquid crystal panel.

Recent display devices include stereoscopic display devices capable of allowing the viewer to see stereoscopic images. For such a stereoscopic display device, including a switch liquid crystal panel is proposed to switch between 2D display and 3D display.

A stereoscopic display device including a switch liquid crystal panel may include a touch panel. In this case, it is necessary to prevent a malfunction of the touch panel while maintaining 3D capability.

DISCLOSURE OF THE INVENTION

An object of the present invention is to provide a stereoscopic display device that is capable of preventing a malfunction of the touch panel while maintaining 3D capability.

A stereoscopic display device according to an embodiment of the present invention includes: a display panel; a switch liquid crystal panel; a touch panel; a driving circuit; and an RC circuit. The display panel displays a composite image having stripe-shaped right eye sub-images and left eye sub-images arranged alternately. The switch liquid crystal panel is located on a front side of the display panel and is capable of forming a parallax barrier having transparent portions for transmitting light and light-shielding portions for blocking light arranged alternately. The touch panel is located on a front side of the switch liquid crystal panel. The driving circuit drives the switch liquid crystal panel to form the parallax barrier. The RC circuit is located between the switch liquid crystal panel and the driving circuit. The driving circuit drives the switch liquid crystal panel using a voltage with an effective value of 3 volts or more.

The stereoscopic display device according to an embodiment of the present invention is capable of preventing a malfunction of the touch panel while maintaining 3D capability.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a conceptual schematic diagram of an exemplary stereoscopic display device according to a first embodiment of the present invention.

FIG. **2** is a schematic cross-sectional view of an exemplary switch liquid crystal panel.

FIG. **3** is a cross-sectional view of a parallax barrier formed in the switch liquid crystal panel.

FIG. **4** is a time chart showing a waveform of a voltage applied to the switch liquid crystal panel.

FIG. **5** is a graph illustrating luminance versus angle θ.

FIG. **6** is a graph illustrating crosstalk ratio versus angle θ.

FIG. **7** is a graph illustrating the effective value of a voltage.

FIG. **8** is a graph showing experiment data that indicates that the crosstalk ratio is not more than 5% if the effective value of a voltage is 3 volts or more.

FIG. **9** is a graph showing other experiment data that indicates that the crosstalk ratio is not more than 5% if the effective value of a voltage is 3 volts or more.

FIG. **10** is a graph showing still other experiment data that indicates that the crosstalk ratio is not more than 5% if the effective value of a voltage is 3 volts or more.

FIG. **11** is a schematic cross-sectional view of an exemplary switch liquid crystal panel included in a stereoscopic display device according to an application example of the first embodiment.

FIG. **12** is a schematic cross-sectional view of an exemplary switch liquid crystal panel included in a stereoscopic display device according to a second embodiment of the present invention, showing the cross-section along XII-XII of FIG. **13**.

FIG. **13** shows the cross-section along XIII-XIII of FIG. **12**.

FIG. **14** is a cross-sectional view of the panel where one of the two parallax barriers that may be formed in the switch liquid crystal panel employed in the second embodiment is formed.

FIG. **15** is a cross-sectional view of the panel where the other one of the two parallax barriers that may be formed in the switch liquid crystal panel employed in the second embodiment is formed.

FIG. **16** is a graph showing experiment data from the second embodiment that indicates that the crosstalk ratio is not more than 5% if the effective value of a voltage is 3 volts or more.

FIG. **17** is a graph showing other experiment data from the second embodiment that indicates that the crosstalk ratio is not more than 5% if the effective value of a voltage is 3 volts or more.

EMBODIMENTS FOR CARRYING OUT THE INVENTION

A stereoscopic display device according to an embodiment of the present invention includes: a display panel; a switch liquid crystal panel; a touch panel; a driving circuit; and an RC circuit. The display panel displays a composite image having stripe-shaped right eye sub-images and left eye sub-images arranged alternately. The switch liquid crystal panel is located on a front side of the display panel and is capable of forming a parallax barrier having transparent portions for transmitting light and light-shielding portions for blocking light arranged alternately. The touch panel is located on a front side of the switch liquid crystal panel. The driving circuit drives the switch liquid crystal panel to form the parallax barrier. The RC circuit is located between the switch liquid crystal panel and the driving circuit. The driving circuit drives the switch liquid crystal panel using a voltage with an effective value of 3 volts or more (first arrangement).

In the first arrangement, the driving circuit may drive the switch liquid crystal panel to form a parallax barrier. The parallax barrier separates a composite image being displayed on the display panel into sub-images. Thus, only the right eye sub-images reach the right eye of the viewer, and only the left eye sub-images reach the left eye of the viewer. As a result, the viewer sees a stereoscopic image.

An RC circuit is provided between the switch liquid crystal panel and driving circuit. The circuit is capable of blunting the waveform of a voltage for driving the switch liquid crystal panel. As a result, the touch panel is less susceptible to noise.

Blunting the waveform of a voltage for driving the switch liquid crystal panel reduces the effective value of the voltage. A reduction in the effective value of the voltage impairs the ability of the light-shielding portions to block light. That is, the light-shielding capability of the parallax barrier decreases. As a result, sufficient 3D capability cannot be achieved.

In the first arrangement, the effective value of a voltage for driving the switch liquid crystal panel is 3 volts or more. This will suppress the reduction in the light-shielding capability of a parallax barrier. As a result, the intended 3D capability may be maintained.

In a second arrangement, starting from the first arrangement, the switch liquid crystal panel includes: a pair of substrates; a liquid crystal layer; a common electrode; and first driving electrodes. The liquid crystal layer is enclosed between the substrates. The common electrode is provided on one of the substrates. The first driving electrodes are provided on the other one of the substrates. The light-shielding portions are formed as the driving circuit applies to the first driving electrodes a voltage different from that applied to the common electrode.

In a third arrangement, starting from the second arrangement, first auxiliary electrodes are included. The first auxiliary electrodes are provided on the other one of the substrates, the first driving electrodes and the first auxiliary electrodes being arranged alternately. The common electrode includes second driving electrodes and second auxiliary electrodes. The second driving electrodes are provided on the one of the substrates. The second auxiliary electrodes are provided on the one of the substrates, the second driving electrodes and the second auxiliary electrodes being arranged alternately. The first driving electrodes are perpendicular to the second driving electrodes as viewed looking at the front side of the switch liquid crystal panel. First light-shielding portions are formed as the driving circuit applies to the first driving electrodes a voltage different from that for the second driving electrodes and the second auxiliary electrodes. Second light-shielding portions are formed that are perpendicular to the first light-shielding portions as the driving circuit applies to the second driving electrodes a voltage different from that for the first driving electrodes and the first auxiliary electrodes.

In this case, touch sensor capability may be provided in a stereoscopic display device that supports landscape and portrait modes.

In a fourth arrangement, starting from the second arrangement, the one of the substrates is located on the touch panel. The common electrode overlies the entire liquid crystal layer as viewed looking at the front side of the switch liquid crystal panel. The RC circuit includes a capacitor. The capacitor has one terminal connected with the common electrode and the other terminal that is grounded.

In this case, the common electrode functions as a shield. Thus, the touch panel is less susceptible to noise generated when the switch liquid crystal panel is being driven. Capacitor having one terminal connected with the common electrode encompasses one of the electrodes of the capacitor being the common electrode or being connected with the common electrode via a line connected with it.

In a fifth arrangement, starting from the fourth arrangement, the capacitor includes the common electrode. Thus, one of the electrodes of the capacitor is implemented using the common electrode. This results in a smaller number of components.

In a sixth arrangement, starting from one of the first to fifth arrangements, the RC circuit has a cutoff frequency that is equal to or smaller than a driving frequency for the touch panel. Thus, the touch panel is less susceptible to noise.

In a seventh arrangement, starting from the sixth arrangement, the cutoff frequency is 70% of the driving frequency or smaller. Thus, the touch panel is still less susceptible to noise.

In an eighth arrangement, starting from the second or third arrangement, that one of the substrates which is located adjacent the touch panel serves as a base substrate of the touch panel. Thus, the stereoscopic display device has a smaller thickness.

Now, more specific embodiments of the present invention will be described with reference to the drawings. The same or corresponding components in the drawings are labeled with the same characters and their description will not be repeated. For ease of explanation, the drawings to which reference will be made hereinafter show simplified or schematic representation, or do not show some components. The size ratios of the components shown in the drawings do not necessarily represent the actual size ratios.

First Embodiment

A stereoscopic display device **10** according to a first embodiment of the present invention will be described with reference to FIG. **1**. The stereoscopic display device **10** may be used in a mobile phone, portable digital assistance, game machine or digital camera, for example.

Overall Construction

The stereoscopic display device **10** includes a display panel **12**, a switch liquid crystal panel **14**, a driving circuit **16**, an RC circuit **18** and a touch panel **20**. The RC circuit **18** includes a resistor **22** and a capacitor **24**.

Display Panel

The display panel **12** may be any panel that is capable of displaying sub-images for effecting stereoscopy (right eye and left eye sub-images). The display panel **12** may be, for example, a liquid crystal panel, or may be a plasma display panel, organic electroluminescent (EL) panel or inorganic EL panel.

The display panel **12** includes a plurality of pixels. The pixels may be arranged in a matrix, for example.

The display panel **12** has columns of pixels for displaying sub-images to be seen by the right eye of the viewer (right eye sub-images) and columns of pixels for displaying sub-images to be seen by the left eye of the viewer (left eye sub-images) arranged alternately in a horizontal direction of the display panel **12**. That is, each right eye or left eye sub-image is divided into sub-images each corresponding to a pixel column (i.e. into stripes). Then, a composite image including these stripe-shaped right eye and left eye sub-images arranged alternately is displayed on the display panel **12**.

Although not shown, the display panel **12** has a driver connected thereto for driving the display panel **12**.

Switch Liquid Crystal Panel

The switch liquid crystal panel **14** is located on the front side of the display panel **12**. The switch liquid crystal panel **14** is capable of forming a parallax barrier. A parallax barrier includes transparent portions for transmitting light and light-shielding portions for blocking light arranged alternately. A parallax barrier divides a composite image displayed on the display panel **12** into sub-images. As such, only right eye sub-images reach the right eye of the viewer and only left eye sub-images reach the left eye of the viewer.

The switch liquid crystal panel **14** will be described with reference to FIG. **2**. The switch liquid crystal panel **14** includes a pair of substrates **26** and **28**, and a liquid crystal layer **30** enclosed between the substrates **26** and **28**.

The substrates **26** and **28** may be any translucent substrates. The substrates **26** and **28** may be, for example, alkali-free glass substrates.

The liquid crystal layer **30** is enclosed between the substrates **26** and **28** as it is sealed in by seal members **32**. The operating mode of the liquid crystal may be, for example, the TN mode.

A common electrode **34** is provided on the substrate **26**. The common electrode **34** may be any transparent conductive film. The common electrode **34** may be, for example, an indium tin oxide film. The common electrode **34** overlies the entire liquid crystal layer **30** as viewed looking at the front side of the switch liquid crystal panel **14**. That is, the common electrode **34** covers an area that overlies the entire area covered by a parallax barrier.

A plurality of driving electrodes (first driving electrodes) **36** are provided on the substrate **28**. Each of the driving electrodes **36** extends in a vertical direction of the switch liquid crystal panel **14** (vertical direction) with a generally constant width. The driving electrodes **36** are arranged in a horizontal direction of the switch liquid crystal panel **14** (horizontal direction) at regular intervals.

Driving Circuit

The driving circuit **16** drives the switch liquid crystal panel **14** to form a parallax barrier. The parallax barrier **38** formed in the switch liquid crystal panel **14** will be described with reference to FIG. **3**.

To form a parallax barrier **38**, the driving circuit **16** applies to the driving electrodes **36** a voltage different from that applied to the common electrode **34**. This changes the orientation of liquid crystal molecules located between the driving electrodes **36** and common electrode **34**. Thus, as viewed looking at the front side of the switch liquid crystal panel **14**, the portions of the panel that cover the driving electrodes **36** serve as light-shielding portions, while the portions between the light-shielding portions **40** serve as transparent portions **42**. As a result, a parallax barrier **38** having light-shielding portions **40** and transparent portions **42** arranged alternately is formed in the switch liquid crystal panel **14**. As a parallax barrier **38** is formed, a composite image displayed on the display panel **12** is divided into sub-images. As a result, only right eye sub-images reach the right eye of the viewer and only left eye sub-images reach the left eye of the viewer.

To form a parallax barrier **38**, voltages may be applied to the electrodes **34** and **36** where the voltage applied to the driving electrodes **36** and the voltage applied to the common electrode **34** are in opposite phases, for example, or where a voltage is applied to the driving electrodes **36** while the common electrode **34** is grounded.

In the implementation shown in FIG. **2**, the driving circuit **16** is provided on the substrate **28**; alternatively, the driving circuit **16** may be provided elsewhere than on the substrate **28**.

RC Circuit

The RC circuit **18** (see FIG. **1**) is located between the switch liquid crystal panel **14** and driving circuit **16**. The RC circuit **18** blunts the waveform of a voltage applied to the switch liquid crystal panel **14**.

The resistor **22** (see FIG. **1**) of the RC circuit **18** is implemented using a line for applying a voltage to the switch liquid crystal panel **14** (i.e. a line for applying a voltage between the common electrode **34** and driving electrodes **36**). This line may include, for example, an extended line provided on the substrate **28**.

The capacitor **24** (see FIG. **1**) of the RC circuit **18** is connected with the line for applying a voltage to the switch liquid crystal panel **14**. In implementations where this line includes an extended line provided on the substrate **28**, one terminal of the capacitor **24** is connected with the extended line on the substrate. The other terminal of the capacitor **24** is grounded. This other terminal of the capacitor **24** may be grounded in any manner. This other terminal of the capacitor **24** may be, for example, grounded via the grounding wire of the driving circuit **16**.

The cutoff frequency of the RC circuit **18** is taken into consideration when setting the capacitance of the capacitor **24**. The cutoff frequency is equal to or smaller than the driving frequency of the touch panel **20**, and, preferably, 70% of the driving frequency of the touch panel **20** or smaller. Thus, the touch panel **20** is less susceptible to noise even when the driving frequency of the touch panel **20** changes due to a change in temperature, for example.

Touch Panel

The touch panel **20** is located on the front side of the switch liquid crystal panel **14**. The touch panel **20** may be any panel that is capable of detecting touch locations. The touch panel **20** may be, for example, an electrostatic capacitance touch panel.

In the implementation shown in FIG. **2**, the base substrate of the touch panel **20** is implemented using the substrate **26** of the switch liquid crystal panel **14**. That is, in implementations where the touch panel **20** is an electrostatic capacitance touch panel, touch electrodes **44** are provided on the substrate **26**, as shown in FIG. **2**. The touch electrodes **44** are covered with a protection film **46**.

Although not shown, a controller is connected with the touch panel **20** for controlling the touch panel **20**.

In the stereoscopic display device **10**, a parallax barrier **38** is formed to separate a composite image displayed on the display panel **12** into sub-images. Thus, only right eye sub-images reach the right eye of the viewer and only left eye sub-images reach the left eye of the viewer. As a result, the viewer sees a stereoscopic image without using special glasses.

An RC circuit **18** is located between the switch liquid crystal panel **14** and driving circuit **16**. Thus, the waveform of a voltage applied to the switch liquid crystal panel **14** may be blunted, as shown in FIG. **4**. As such, the touch panel **20** is less susceptible to noise.

Blunting the waveform of a voltage applied reduces the effective value of the voltage. A reduction in the effective value of the voltage impairs the ability of the light-shielding portions **40** to block light. That is, the light-shielding capability of the parallax barrier **38** decreases. As a result, the crosstalk ratio increases and sufficient 3D capability cannot be achieved.

Crosstalk ratio indicates how much the black display level increases relative to the background level (produced when both the left and right eye sub-images are displayed in black) when, for example, the parallax barrier **38** is formed in the switch liquid crystal panel **14** and one of the group of pixels for left eye sub-images and the group of pixels for right eye sub-images displays white and the other one displays black. Crosstalk ratio may serve as an indicator of to what extent, given a right eye sub-image and a left eye sub-image, one is projected in the other.

Crosstalk ratio is defined by the following equations (1) and (2):

$$LXT=\{(BL(\eta)-CL(\eta))/(AL(\eta)-CL(\eta))\}\times 100 \quad (1), \text{ and}$$

$$RXT=\{(AR(\eta))/CR(\eta))/(BR(\eta)-CR(\eta))\}\times 100 \quad (2)$$

LXT denotes the crosstalk ratio for the left eye, and RXT denotes the crosstalk ratio for the right eye. η denotes the angle η. As shown in FIG. **5**, AL(η) represents the luminance of an image seen by the left eye according to graph G**1**, AR(η) represents the luminance of an image seen by the right eye according to graph G**1**, BL(η) represents the luminance of an image seen by the left eye according to graph G**2**, BR(η) represents the luminance of an image seen by the right eye according to graph G**2**, CL(η) represents the luminance of an image seen by the left eye according to graph G**3**, and CR(η) represents the luminance of an image seen by the right eye according to graph G**3**. The crosstalk ratio obtained from the above equations (1) and (2) is at the minimum for the eye points (angle $\eta=\pm\eta 0$), as shown in FIG. **6**. In the following description, crosstalk ratio means the crosstalk ratio for the eye points. Generally, the lower the crosstalk ratio, the better 3D display can be achieved and the less the human body will be affected.

The effective value of a voltage applied to the switch liquid crystal panel **14** is 3 volts or more. This will suppress the reduction in the light-shielding capability of the parallax barrier **38**. That is, the crosstalk ratio will be reduced. As a result, the intended 3D capability may be maintained.

The effective value of a voltage may be represented by the area of the hatched portion in FIG. **7**. The effective value of a voltage may be defined by the following equation (3):

[Expression 1]

$$\int_0^{\frac{T}{2}} V(t)\,dt \quad (3)$$

V(t) represents the magnitude of the drive voltage for time t. T denotes the cycle of the drive voltage wave.

For the effective value of a voltage to be 3 volts or more, the following equation (4) must be satisfied:

[Expression 2]

$$\int_0^{\frac{T}{2}} V(t)\,dt \geq 1.5\ T \quad (4)$$

If the effective value of a voltage is 3 volts or more, the crosstalk ratio is 5% or smaller, as shown in FIGS. **8** to **10**. Generally, if the crosstalk ratio is 5% or smaller, good 3D display can be achieved.

FIGS. **8** and **10** are graphs showing data from experiments conducted on a switch liquid crystal panel **14** having such liquid crystal as described below. In these experiments, the operating mode of the liquid crystal was the TN, normally white mode. The retardation of the liquid crystal was the value corresponding to the first maximum in a graph illustrating light transmission versus retardation in normally white mode.

FIG. **9** is a graph showing data from experiments conducted on a switch liquid crystal panel **14** having such liquid crystal as described below. In these experiments, the operating mode of the liquid crystal was the TN, normally white mode. The retardation of the liquid crystal was the value corresponding to the second maximum in a graph illustrating light transmission versus retardation in normally white mode.

In FIGS. **8** to **10**, broken lines represent the crosstalk ratio for the right eye point, while solid lines represent the crosstalk ratio for the left eye point.

As shown in FIGS. **8** to **10**, the crosstalk ratio is 5% or less if the effective value of a voltage is 3 volts or more in any of these implementations.

Application Example of First Embodiment

The above one terminal of the capacitor **24** need not be connected with a line for applying a voltage between the common electrode **34** and driving electrodes **36**. For example, the one shown in FIG. **11**, the one terminal of the capacitor **24** may be connected with the common electrode **34**.

Second Embodiment

The present embodiment has a different switch liquid crystal panel from that of the first embodiment. As shown in FIGS. **12** and **13**, in the switch liquid crystal panel **50** of the present embodiment, auxiliary electrodes (first auxiliary electrodes) **52** are provided on the substrate **28**. The auxiliary electrodes **52** extend in a vertical direction of the switch liquid crystal panel **50** with a predetermined width. Each of the auxiliary electrodes **52** is located between two adjacent driving electrodes (first driving electrodes) **36**. That is, the driving electrodes **36** and auxiliary electrodes **52** are arranged alternately. The auxiliary electrodes **52** may be from any transparent conductive film. For example, the auxiliary electrodes **52** may be from an indium tin oxide film.

In the switch liquid crystal panel **50** of the present embodiment, the common electrode **34** is not provided on the substrate **26**. Instead, driving electrodes (second driving electrodes) **54** and auxiliary electrodes (second auxiliary electrodes) **56** are arranged alternately. These electrodes **54** and **56** are arranged in a direction perpendicular to the direction in which the electrodes **36** and **52** on the substrate **28** are arranged. The driving electrodes **54** and auxiliary electrodes **56** extend in a horizontal direction of the switch liquid crystal panel **50** with a generally constant width. The driving electrodes **54** and auxiliary electrodes **56** may be from any transparent conductive film. For example, the driving electrodes **54** and auxiliary electrodes **56** may be from an indium tin oxide film.

The switch liquid crystal panel **50** forms a parallax barrier in the following manner.

A parallax barrier **58** will be described with reference to FIG. **14**. The parallax barrier **58** may be formed by causing the auxiliary electrodes **52**, driving electrodes **54** (see FIG. **13**) and auxiliary electrodes **56** to be at the same potential (0 volts, for example) and causing the driving electrodes **36** to be at a potential different from that of the electrodes **52**, **54** and **56** (5 volts, for example). This changes the orientation of liquid crystal molecules located between the driving electrodes **36** and the driving electrodes **54** and auxiliary electrodes **56** that serve as a common electrode. Thus, those portions of the liquid crystal that overlie the driving electrodes **36** as viewed looking at the front side of the switch liquid crystal panel **50** function as light-shielding portions **60**, while the portions between the light-shielding portions **60** function as transparent portions **62**. As a result, the parallax barrier **58** including light-shielding portions **60** and transparent portions **62** arranged alternately is formed in the switch liquid crystal panel **50**.

To form the parallax barrier **58**, voltages may be applied to the electrodes **36**, **52**, **54** and **56** where the voltage applied to the driving electrodes **36** and the voltage applied to the other electrodes **52**, **54** and **56** are in opposite phases, for example, or where a voltage is applied to the driving electrodes **36** while the other electrodes **52**, **54** and **56** are grounded.

In the present embodiment, a parallax barrier different from the parallax barrier **58** may be formed.

A parallax barrier **64** will be described with reference to FIG. **15**. The parallax barrier **64** may be formed by causing the auxiliary electrodes **56**, driving electrodes **36** (see FIG. **12**) and auxiliary electrodes **52** to be at the same potential (0 volts, for example) and causing the driving electrodes **54** to be at a potential different from that of the electrodes **36**, **52** and **56** (5 volts, for example). This changes the orientation of liquid crystal molecules located between the driving electrodes **54** and the driving electrodes **36** and auxiliary electrodes **52** that serve as a common electrode. Thus, those portions of the liquid crystal that overlie the driving electrodes **54** as viewed looking at the front side of the switch liquid crystal panel **50** function as light-shielding portions **66**, while the portions between the light-shielding portions **66** function as transparent portions **68**. As a result, the parallax barrier **64** including light-shielding portions **66** and transparent portions **68** arranged alternately is formed in the switch liquid crystal panel **50**.

The light-shielding portions **66** and transparent portions **68** of the parallax barrier **64** are arranged alternately in a direction that is perpendicular to the direction in which the light-shielding portions **60** and transparent portions **62** of the parallax barrier **58** are arranged alternately.

To form the parallax barrier **64**, voltages may be applied to the electrodes **36**, **52**, **54** and **56** where the voltage applied to the driving electrodes **54** and the voltage applied to the other electrodes **36**, **52** and **56** are in opposite phases, for example, or where a voltage is applied to the driving electrodes **54** while the other electrodes **36**, **52** and **56** are grounded.

In the present embodiment, two parallax barriers **58** and **64** may be formed. The light-shielding portions **66** and transparent portions **68** of the parallax barrier **64** are arranged alternately in a direction that is perpendicular to the direction in which the light-shielding portions **60** and transparent portions **62** of the parallax barrier **58** are arranged alternately. Thus, in the present embodiment, a stereoscopic display device that supports landscape and portrait modes may be realized.

In the present embodiment, too, as shown in FIGS. **16** and **17**, the crosstalk ratio is 5% or less if the effective value of a voltage is 3 volts or more.

FIGS. **16** and **17** are graphs showing data from experiments conducted on a switch liquid crystal panel **50** having such liquid crystal as described below. In these experiments, the operating mode of the liquid crystal was the TN, normally white mode. The retardation of the liquid crystal was the value corresponding to the first maximum in a graph illustrating light transmission versus retardation in normally white mode.

In FIGS. **16** and **17**, broken lines represent the crosstalk ratio for the right eye point, while solid lines represent the crosstalk ratio for the left eye point.

In the present embodiment, too, the crosstalk ratio is 5% or less if the effective value of a voltage is 3 volts or more, as shown in FIGS. **16** and **17**.

While embodiments of the present invention have been described in detail, they are merely illustrative examples and the present invention is not limited in any way to the above embodiments.

The invention claimed is:

1. A stereoscopic display device, comprising:

a display panel configured to display a composite image having stripe-shaped right eye sub-images and left eye sub-images arranged alternately;

a switch liquid crystal panel located on a front side of the display panel and capable of forming a parallax barrier having transparent portions for transmitting light and light-shielding portions for blocking light arranged alternately;

a touch panel located on a front side of the switch liquid crystal panel;

a driving circuit configured to drive the switch liquid crystal panel to form the parallax barrier; and

an RC circuit located between the switch liquid crystal panel and the driving circuit,

wherein the driving circuit drives the switch liquid crystal panel using a voltage with an effective value of 3 volts or more.

2. The stereoscopic display device according to claim **1**, wherein:

the switch liquid crystal panel includes:

a pair of substrates;

a liquid crystal layer enclosed between the substrates;

a common electrode provided on one of the substrates; and

first driving electrodes provided on the other one of the substrates, and

the light-shielding portions are formed as the driving circuit applies to the first driving electrodes a voltage different from that applied to the common electrode.

3. The stereoscopic display device according to claim **2**, further comprising:

first auxiliary electrodes provided on the other one of the substrates, the first driving electrodes and the first auxiliary electrodes being arranged alternately,

the common electrode includes:

second driving electrodes provided on the one of the substrates; and

second auxiliary electrodes provided on the one of the substrates, the second driving electrodes and the second auxiliary electrodes being arranged alternately,

the first driving electrodes are perpendicular to the second driving electrodes as viewed looking at the front side of the switch liquid crystal panel,

first light-shielding portions are formed as the driving circuit applies to the first driving electrodes a voltage different from that for the second driving electrodes and the second auxiliary electrodes, and

second light-shielding portions are formed that are perpendicular to the first light-shielding portions as the driving circuit applies to the second driving electrodes a voltage different from that for the first driving electrodes and the first auxiliary electrodes.

4. The stereoscopic display device according to claim **2**, wherein:

the one of the substrates is located on the touch panel,

the common electrode overlies the entire liquid crystal layer as viewed looking at the front side of the switch liquid crystal panel,

the RC circuit includes a capacitor, and the capacitor has one terminal connected with the common electrode and the other terminal that is grounded.

5. The stereoscopic display device according to claim **1**, wherein the RC circuit has a cutoff frequency that is equal to or smaller than a driving frequency for the touch panel.

6. The stereoscopic display device according to claim **5**, wherein the cutoff frequency is 70% of the driving frequency or smaller.

7. The stereoscopic display device according to claim **2**, wherein that one of the substrates which is located adjacent the touch panel serves as a base substrate of the touch panel.

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